GC Verification of the Spacecraft Atmosphere Monitor

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Background

International Space Station(ISS) crew members face the unique challenge of maintaining air quality due to volatile organic compounds (VOCs) that have the potential to accumulate at unsafe levels. Crew members perform scientific experiments which could involve VOCs, leading to a potential hazard in combining with other compounds in the atmosphere of the cabin. **Figure 5** shows a flight engineer setting up a glovebox for experiments on the ISS. In addition, humans emit acetone and ammonia in small quantities, not harmful on Earth due to the diffusion through the large atmosphere. However in a spacecraft, these VOCs can accumulate in significant and hazardous amounts if not carefully monitored.

The Spacecraft Atmosphere Monitor (SAM) is a miniature gas chromatograph/mass spectrometer(GCMS) designed to measure major constituents (such as N_2, O_2 and CO_2), and trace VOCs within the cabin of the spacecraft. The SAM is designed to scan for these compounds more efficiently than its predecessor the Vehicle Cabin Atmosphere Monitor (VCAM). A new design calls for much testing regarding the new components, specifically the preconcentrator (PC) and gas chromatograph (GC). These instruments are designed to separate the components of the atmosphere for characterization.

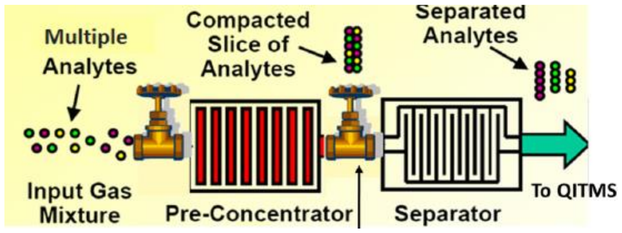

Figure 1. Illustration of a preconcentrator (PC) and separator/gas chromatograph (GC).

Gas Chromatograph

The oven of the gas chromatograph must reach a temperature of 150 °C in order to heat, to boiling point, all components needing to be tested.

Preconcentrator

The preconcentrator is responsible for flash heating the compounds acquired from the cabin atmosphere. This is important for high gain PC and strong peak separation of the GC.

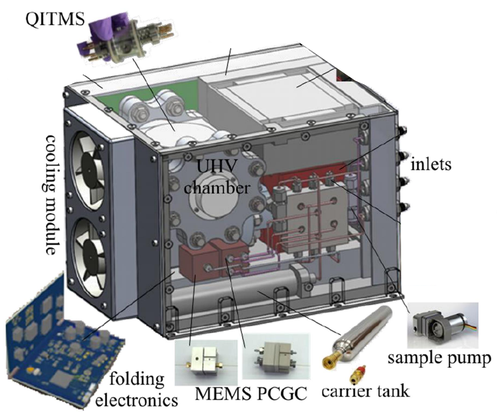

Figure 2. Detailed model of SAM.

Methods

The proper heating parameters were determined for the gas chromatograph component of the SAM. Indium pads were used as the conducting surface to provide electrical connection from the external lead wires. To test the maximum voltage needed for the Minco heater used in the GC, a series of experiments was conducted. When comparing voltages, the time to reach each operating temperature was of interest as well. Test voltages began at 10 V up to 22 V in increments of 2V, the heating stopped when the temperature of the heater reached 150 °C. **Figure 3** displays the experimental setup.

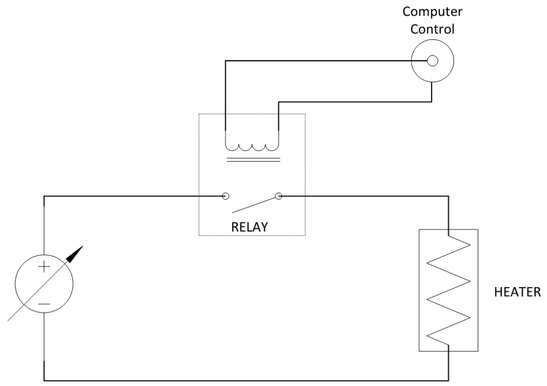

Figure 3. Schematic of the SAM GC heater testing.

SAM Specifications (vs VCAM)

Quantity	SAM	VCAM
Mass (kg)	9.5	37.9
Dimensions (in)	9.5x8.75x7.5	10.8x18.1x20.4
Volume (L)	10	64.4
Average Power (W)	45	120
Start Up Time (min)	<2	150
MCA Time	2 s	3-5 hours
TGA Time	10 min	40 min
Carrier Gas (cc/min)	0.1 (H_2)	1.2 (He)
Valve Power (W)	<1	12
PC Gain	400	100
GC Injector	MEMS MV	Large valves
GC Column	MC (2 m)	Column (10 m)
Elution Time (min)	<10	20
QIT Size (mm)	10	10
Vacuum Pump (L/s)	6 (ion/getter)	70 (turbo)
Thermal Control	convection/conduction	convection

Table 1. Comparison of the SAM and VCAM instruments.

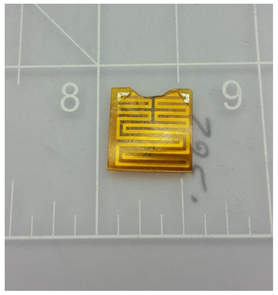

Figure 4. An example of the heater used in the GC. (display scale in inches)

Figure 5. Expedition 42 Flight Engineer Terry Virts sets up the Microgravity Science Glovebox in the ISS. **Source:** http://www.nasa.gov/mission_pages/station/research/news/micro_5

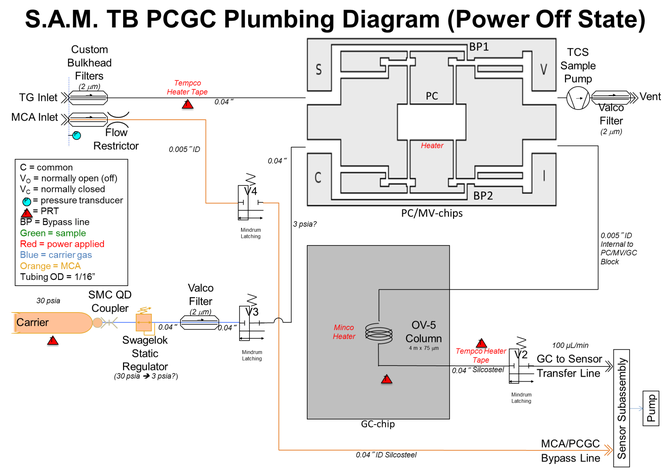

Figure 6. The plumbing schematic of the SAM.

Results

A maximum voltage of 22 V led to immediate heater failure. The GC was tested for leaks and proved that no thermal shock on the column would occur at or below 22 volts. At 12 volts, the heating time was insufficient, over 30 minutes. A week long test proved that 14 V would be a sufficient voltage to heat the gas chromatograph at a reasonable rate, under 10 minutes.

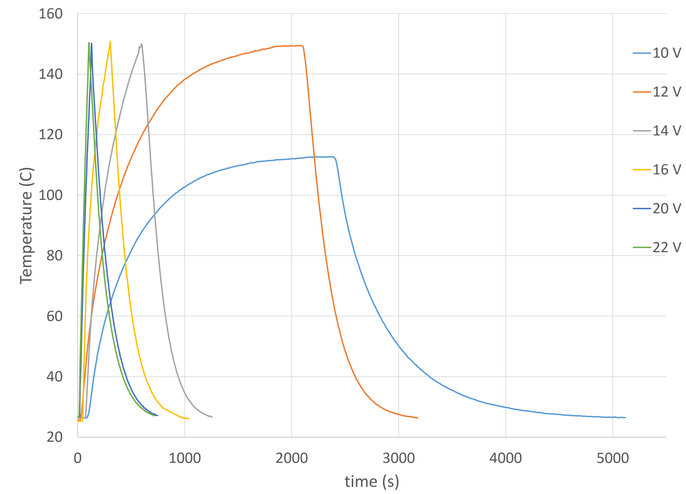

Figure 7. GC heater testing for different voltages.

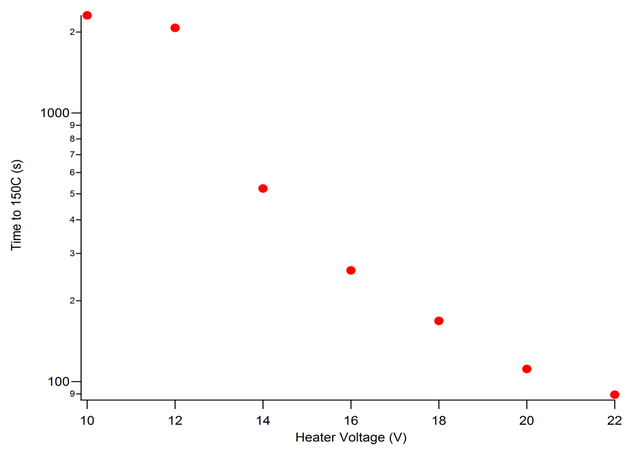

Figure 8. A graph of the time to reach the maximum temperature for each voltage

Discussion

The GC heater was successfully characterized. A week long test proved that 14 V would be a sufficient voltage to heat the gas chromatograph at a reasonable rate. Further work regarding the adequate operating parameters for the preconcentrator(i.e. the required voltage to flash heat effectively), and other components, such as electronics, of the SAM must be tested and verified before implementation on the ISS and, potentially, other future spacecraft.

Acknowledgements
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